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SUMMARIES OF CURRENT NORTH AMERICAN PRE-CAMBRIAN LITERATURE.

(*Continued from p. 425, Vol. VII.*)

WALCOTT[1] discusses pre-Cambrian fossiliferous formations of North America. In two cases only have fossils of undoubted organic origin been shown to occur in formations of reasonably certain pre-Cambrian age, namely, the Grand Canyon of Arizona, and the Belt terrane of Montana. The Etcheminian terrane of New Brunswick and Newfoundland is doubtfully a third instance.

A brief account is given of the stratigraphy of each of the areas of pre-Cambrian sedimentary rocks. No new points appear except in the description of the Belt terrane of Montana; the account of the Belt terrane is therefore the only one summarized with reference to stratigraphy.

The Belt terrane of Montana covers an area of more than 6000 square miles in central Montana. The principal beds of the terrane are as follows:

Marsh shales - - - - - - - -	300 feet.
Helena limestone - - - - - - -	2,400 "
Empire shales - - - - - - - -	600 "
Spokane shales - - - - - - -	1,500 "
Greyson shales - - - - - - - -	3,000 "
Newland limestone - - - - - -	2,000 "
Chamberlin shales - - - - - - -	1,500 "
Neihart quartzite and sandstone - - -	700 "
	12,000 feet.

Throughout the area the Belt terrane is overlain unconformably by middle Cambrian rocks (Flathead). The Cambrian rocks rest on various members of the Belt series, and in places the Belt terrane is entirely wanting, the Cambrian resting directly on the Archean schists. In such cases, moreover, the character of the Belt beds indicates that the Cambrian overlaps the Belt series. The base of the Cambrian is not markedly conglomeratic. At most of the outcrops where the lower beds of the Flathead (Cambrian) sandstone come in contact with the Belt rocks the dip and strike of the two are usually conformable, so far as can be determined by measurement. This holds good all around the great Belt Mountain uplift. It is only when contacts are examined in detail, as near Helena, that the minor unconformities are discovered, and only when comparisons are made between sections at some distance from one another that the extent of the unconformity becomes apparent. In general from 3000 to 4000 feet of the upper strata of the Belt terrane were removed by erosion in late Algonkian time before the Middle Cambrian was deposited. It is believed that an unconformity of this extent is sufficient to explain the absence of Lower Cambrian rocks and fossils and to warrant the placing of the Belt terrane in the Algonkian system.

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[1] Pre-Cambrian Fossiliferous Formations, by CHARLES D. WALCOTT: Bull. Geol. Soc. Am., Vol. X, 1899, pp. 199–244.

The fossils thus far found in the Belt terrane occur in the Greyson shales at a horizon approximately 7700 feet beneath the summit of the Belt terrane at its maximum development. The fauna includes four species of annelid trails and a variety that appears to have been made by a minute mollusk or crustacean. There also occur in the same shales thousands of fragments of one or more genera of crustaceans.

Grand Canyon series.—The fossils of the Grand Canyon Upper Cambrian series consist of specimens of a small discinoid shell found in the upper division of the Chuar terrane, and a Stromatopora-like form from the upper portion of the lower division and the central portion of the upper division of the Chuar. Other obscure forms appear whose identification is doubtful.

In New Brunswick certain rocks below the middle Cambrian, according to Matthew, contain fossils which may be pre-Cambrian. (See summary of Matthew's articles, following, p. 435, and of later article by Walcott, p. 436.)

The Llano series of Texas is a series of alternating sandy shales, sandstone, and limestone, very similar to those of the Grand Canyon pre-Cambrian series and overlain by a middle Cambrian sandstone similar to the Tonto sandstone of the Grand Canyon district. No fossils have been found in these rocks, although no systematic search has been made.

The Avalon series of Newfoundland includes all the pre-Cambrian sedimentary rocks of that area. Overlying them are Cambrian strata carrying olenellus fauna.

The Aspidella of the Momable slates is probably of organic origin, but it may be questioned. Other reported forms are inaccessible for study.

In the Lake Superior country markings have been reported as found in the Huronian iron formation of the Menominee iron district of Michigan. An examination of the specimens indicates that they probably are from the basal detrital material of the Cambrian which rests upon the Huronian iron formation. In the Animikie rocks of the Lake Superior region the evidence of life consists of the presence of graphitic material in the slates and of a supposed fossil mentioned by Mr. G. F. Matthew. In the Minnesota quartzite of the Upper Huronian series lingula-like forms and an obscure trilobitic-looking impression are described by Winchell. The latter has been examined and the conclusion is reached that it is of inorganic origin. As to the lingula forms, the weight of evidence is in favor of their being small flattened concretions.

In general, the reported discoveries of fossils in the crystalline rocks of the Algonkian are as yet too problematic to be of value to the geologist and paleontologist. Apparently the best that can be said of Eozoon and allied forms is that they may be of organic origin, but it is not yet proved. The same appears to be true of the supposed fossil sponges described by Mr. G. F. Matthew from the Laurentian rocks of New Brunswick. The graphite in pre-Cambrian forms is probably in many cases of organic origin, but of the character of the life we know nothing.

Palaeotrochis formerly referred to as a pre-Paleozoic coral is determined by Professor J. A. Holmes and J. S. Diller as of inorganic origin.

Matthew[1] describes a Paleozoic terrane beneath the Cambrian in St. Johns and Kings counties, New Brunswick, on Cape Breton, and near Smith Sound, Newfoundland. This terrane is unconformably below Cambrian strata bearing paradoxides and protolenus fauna, and is given the name *Etcheminian*. The faunal features as distinguished from the Cambrian are the great preponderance of tube worms, absence or rarity of trilobites, minuteness of the gasteropods, except Patellidae, minuteness of the brachiopods, and the minuteness of the crustaceans.

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[1] A Paleozoic Terrane Beneath the Cambrian: Annals N. Y. Acad. Sci., Vol. XII, No. 2, 1899, pp. 41–56.

Preliminary Notice of the Etcheminian Fauna of Newfoundland: Bull. Nat. Hist. Soc., New Brunswick, XVIII, Vol. IV, 1899, pp. 189–197.

Preliminary Notice of the Etcheminian Fauna of Cape Breton: Bull. Nat. Hist. Soc., New Brunswick, XVIII, Vol. IV, 1899, pp. 198–208.

The Etcheminian Fauna of Smith Sound, Newfoundland: Trans. Roy. Soc. of Canada, 2d ser., 1899, Vol. V, sec. 4, pp. 97–119.

Walcott[1] believes the *Etcheminian* terrane of New Brunswick and Newfoundland called pre-Cambrian by Matthew to be of Lower Cambrian age. His evidence is:

1. That the Olenellus fauna in Newfoundland occurs 420 feet beneath the Paradoxides fauna, in the heart of the Lower Cambrian "Etcheminian."

2. That fragments of the fauna are found 460–480 feet below the Protolenus fauna in the "Etcheminian" of the Hanford Brook section of New Brunswick.

3. That in the undisturbed, unbroken Highland Range section of Nevada the Olenellus fauna is 4450 feet below the Upper Cambrian fauna, and that the Olenoides (Dorypyge fauna of Matthew) is 3000 feet below the horizon of the Upper Cambrian fauna and 1450 feet above the horizon of the *Olenellus gilberti* fauna.

4. That in the southern Appalachians the Olenellus fauna occurs more than 7000 feet below the highest Cambrian fauna known in that region, and fully 2000 feet below a typical Olenoides fauna.

Matthew[2] makes rejoinder to Mr. Walcott's discussion of the age of the Etcheminian terrane. He argues that Mr. Walcott depends chiefly upon the presence of Coleoloides typicalis as showing the presence of the Olenellus fauna; that this form is not always distinguishable from Hyolithellus micans, a problematical fossil probably of the tube worms, which, with the brachiopods, is the most striking of the fossils of the lower (Etcheminian) terrane. Moreover, the particular form of Olenellus which Mr. Walcott has found is the Olenellus bröggeri, rather than the Olenellus thompsoni, the original Olenellus. Olenellus thompsoni is supposed to occur above the Olenellus bröggeri, yet the Protolenus and Paradoxides faunas follow in regular succession to the fauna of the Olenellus bröggeri. The question is asked: Where is the fauna of Olenellus thompsoni? Its absence is supposedly taken as evidence of the presence of the unconformity held by Matthew.

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[1] Lower Cambrian Terrane in the Atlantic Province, by C. D. WALCOTT: Proc. Washington Acad. Sci., Vol. I, 1899, pp. 301–339.

[2] Mr. Walcott's View of the Etcheminian, by G. F. MATTHEW: Am. Geol., Vol. XXV, 1900, pp. 255–258.

Emerson[1] describes the Algonkian rocks occurring in the southwestern corner of the Holyoke quadrangle in Massachusetts and in the area to the west. These are gneisses and limestones making up a series called the Washington gneiss. They are of sedimentary origin with the possible exception of the hornblende-gneiss of East Lee.

In general in western Massachusetts the Washington gneiss appears in oval areas surrounded by younger strata, the line of these ovals extending south from the Hoosac Tunnel along the crest of the Green Mountain plateau. The gneiss enters the Holyoke quadrangle at the southwest corner and runs up across the town of Tolland, narrowing to a point near Black Pond.

Woodworth[2] describes the Algonkian rocks in the lower portion of the Blackstone Valley and west of Providence, R. I., near the western margin of the Narragansett basin. From the typical development of the Algonkian rocks along the Blackstone River between Woonsocket and Pautucket, they are called the Blackstone series. This series is divided into the Cumberland quartzites; the Ashton schists, representing the finer sediments succeeding the deposition and partial erosion of the Cumberland quartzites, and in part probably igneous in origin; and the Smithfield limestone, apparently of sedimentary origin. As yet no facts have been discovered to show whether the limestones are of the same age or newer than the Ashton schists. The rocks of the Blackstone series are separated and penetrated by granitic intrusions or batholites.

The Blackstone series is assigned to the Algonkian because of the difference in metamorphism of the Blackstone series and Lower Cambrian strata, bearing Olenellus fauna, in North Attleboro. The Cambrian strata are little altered and lie in close proximity to the granite. Four miles west the Blackstone series is infolded with a similar granite and much altered.

Kemp[3] gives a petrographical account of the granites of the

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[1] B. K. EMERSON: Geology of Old Hampshire County, Massachusetts, comprising Franklin, Hampshire, and Hampden Counties: Mon. U. S. Geol. Surv., No. 29, 1898, pp. 19–30. With geological map. This covers the area of the Holyoke quadrangle and in addition a narrow area to the north and east.

Holyoke folio, Massachusetts-Connecticut: Geol. Atlas of the U. S., No. 50, 1898.

[2] Geology of the Narragansett Basin, Part 2, by J. B. WOODWORTH: Mon. U. S. Geol. Surv., No. 33, 1899, pp. 104–118. With geological map.

[3] Granites of Southern Rhode Island and Connecticut, with Observations on Atlantic Coast Granites in General, by J. F. KEMP: Bull. Geol. Soc. Am., Vol. X, 1899, pp. 361–382; with plates.

Atlantic coast of pre-Cambrian and later age. He finds a striking predominance of biotite granites and gneisses.

Kemp,[1] in connection with a description of the magnetite deposits of the Adirondacks of New York, publishes a geological map of portions of Elizabethtown and Westport townships in Essex county, showing the distribution of the pre-Cambrian magnetite-bearing gabbros, the gneisses, and the limestones. No point in addition to those given in previous reports appears.

Merrill[2] gives a brief summary account of the geological formations of New York, including the pre-Cambrian of the Adirondack area and of the southeastern part of the state. Accompanying the report is a relief map showing the outlines of the geological formations.

Cushing[3] describes an augite-syenite-gneiss near Loon Lake in the Adirondacks. It is nearly related to the anorthosites in age, inasmuch as it is intrusive in the Grenville series, but it is much older than the pre-Potsdam diabases of the region. A study of the relations of the syenites and anorthosites indicates that the syenites are in part a result of differentiation in the anorthosite magma after reaching its place of final cooling, and in part are somewhat later in date.[4]

Smyth[5] summarizes his ideas to date on the geology of the Adirondacks. Gneisses, limestone, and gabbro are the principal rocks. From studies in the western Adirondacks it is certain that some of the gneisses are of igneous origin, being granites syenites, gabbros, etc., which have been modified by metamorphism; while others, with equal certainty, are altered sediments. But by far the larger part of the gneisses have as yet received no careful study. The limestones are certainly sedimentary. Their relations to the gneisses are in doubt, but some parts of the gneisses are certainly younger than the limestones, and this may be true of all. The gabbro breaks through both gneisses and limestones. It presents two phases, an anorthosite, and a gabbro containing abundant pyroxene and other ferro-magnesian minerals. In places also in the western Adirondacks the granites and syenites break through the limestone.

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[1] The Titaniferous Iron Ores of the Adirondacks, by J. F. KEMP: Nineteenth Ann. Rept. U. S. Geol. Surv., 1897–8, Part 3, 1899, pp. 377–422. With geological map.

[2] A Guide to the Study of the Collections of the New York State Museum, by F. J. H. MERRILL: Bull. N. Y. State Museum, Vol. IV, No. 19, 1898, pp. 109–262; with geological map.

[3] Augite-Syenite-Gneiss near Loon Lake, New York, by H. P. CUSHING: Bull. Geol. Soc. of Am., Vol. X, 1899, pp. 177–192.

[4] The anorthosites are a part of the great gabbro mass which forms the core of the Adirondacks intruding pre-Cambrian sedimentary and igneous gneisses.

[5] Geology of the Adirondack Region, by C. H. SMYTH, JR.: Appalachia, Vol. IX, No. 1, May 1899.

Barlow[1] gives a further account of the results of work being carried on by himself and Dr. Adams in the counties of Hastings, Haliburton, and Renfrew, Province of Ontario. Many of the so-called conglomerates of the Hastings and Grenville series are believed to be autoclastic rocks or pseudoconglomerates which have resulted in the main from complex folding and stretching. Therefore such rocks cannot be cited as evidence of the clastic origin of the Hastings and Grenville series, as has been done.

Barlow[2] describes the geology of the Nipissing-Temiscaming map-sheets, comprising portions of the district of Nipissing, Ontario, and the county of Pontiac, Quebec.

Laurentian and Huronian rocks occupy most of the area. These do not include a few small isolated inliers of crystalline limestone and gneissic rocks which resemble the Grenville rocks to the south and southwest. These are so small in quantity that they are not mapped. Their relations to the Huronian are not discussed.

The Laurentian rocks occupy the two thirds of the area of the two sheets. While probably representing in part the first formed crust of the earth, and therefore the basement upon which the Huronian rocks were laid down, the Laurentian has undergone successive fusions and recementations before reaching its present condition. It is now a complex of plutonic rocks which in general show irruptive relations to the overlying Huronian series. However, on Lake Temiscaming the Laurentian is unconformably below, and in direct contact with, an arkose of Huronian age, which has apparently been derived from the disintegration the Laurentian granite.

The Huronian occupies about a third of the combined area of the two sheets. It is separable into three divisions, in ascending order as follows: (1) breccia or breccia-conglomerate, (2) graywacke shale or slate, and (3) feldspathic sandstone or quartzite. The maximum thickness of the first division is 600 feet; of the second, 100 feet; and of the third, 1100 feet. Associated with these clastic rocks are various rocks of igneous origin, including deep-seated diabase and gabbro and volcanic ejectamenta.

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[1] On the Origin of some Archean Conglomerates, by A. E. BARLOW: The Ottawa Naturalist, Vol. XII, 1899, pp. 205–217. See Am. Journ. Sci., 4th series, Vol. III, 1897, pp. 173–180.

[2] Geology and Natural Resources of the Area included by the Nipissing-Temiscaming Map-sheets, comprising Portions of the District of Nipissing, Ontario, and of the County of Pontiac, Quebec, by A. E. Barlow: Ann. Report Geol. Surv. of Canada, Vol. X, Pt. 1, 1899, pp. 302. With geological map.

Comments.—The nature of the relations of the Huronian and Laurentian rocks has so long been a subject of controversy and the ground has been gone over so many times that comment seems unnecessary. But for readers who have not followed the controversy a statement of one of the main points of contention may be of service. The Laurentian rocks of Barlow and other Canadian geologists form the basement upon which the Huronian rocks were deposited, and they also have intrusive relations to the Huronian rocks. This anomaly is explained by the fact that the granites and gneisses really form the basement upon which the Huronian rocks were deposited, but that since this deposition the granites and gneisses have been softened by fusion, perhaps due to the weight of the overlying rocks, and that they now invade the lower portions of the Huronian rocks.

Other geologists, particularly the United States geologists, have maintained that no evidence has been adduced to show that there has been any softening of the basement granites near their contact with the overlying Huronian sediments; that the granites and gneisses included under the Laurentian by the Canadian geologists are of widely different ages; that they comprise both the original basement rocks, in their original form, upon which the Huronian was deposited, and later rocks, intrusive into both the Laurentian and Huronian; and furthermore, that in most regions it will be possible by close areal mapping to distinguish these different granites and gneisses. They would map the basement granites and gneisses as one series, and separate from them all later intrusives.

Although Mr. Barlow has for many years maintained the total absence of the normal erosion unconformity between the Laurentian granite and the Huronian, he now reports the "discovery" of such a contact near Lake Temiscaming. In finding a normal erosion unconformity in this area he is many years behind Pumpelly, Irving, and Van Hise, as indicated in a comment on a previous article of Mr. Barlow.[1] It is thus now agreed that the original basement granites and gneisses are present in this area. Mr. Barlow cites no evidence to show that softening of the granites and gneisses has anywhere occurred immediately subjacent to the sediments, resulting in the invasion of the sediments by the granites and gneisses; that any eruptive relations now found are not those of the normal intrusion of granite magmas into both the original basement and the overlying sediments.

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[1] JOUR. GEOL., Vol. II, p. 419.

Ells[1] gives an historical account of the geological nomenclature of that part of Canada which extends roughly from the Red River of Manitoba eastward over Canada. The present usage with reference to pre-Cambrian rocks may only be mentioned.

In Nova Scotia the term pre-Cambrian has been given to certain old crystalline rocks which were found to underlie the recognized Cambrian of the coast or of the gold-series, and which were found to strongly resemble certain portions of the Laurentian or Huronian of the western provinces.

In New Brunswick there has been little change in the nomenclature proposed by Matthew, Bailey, and Hunt. The lowest division of the crystalline rocks was held to conform most closely in its details to the Laurentian of the Canadian Survey. This series was divided into a lower and an upper division, the former of which was regarded as the equivalent of the Lower or Fundamental Gneiss of the Ottawa district, while the latter was supposed to represent the limestone and gneiss of the Grenville series of Quebec. The Huronian was made to include three divisions, viz., the Colebrook, the Kingston, and the Coastal. Since this time Matthew has introduced the term Etcheminian to designate certain fossiliferous sediments found beneath the middle Cambrian, probably belonging to the more recent portion of the pre-Cambrian formations.

In Ontario and Quebec the oldest granite-gneiss may be styled Laurentian. The second member of the scale, or the Huronian, may be made to include, as its lowest portion, that part of the crystalline series, once regarded also as part of the Laurentian system, and known locally under the names Grenville and Hastings series, the relations of which to the Laurentian proper are apparently of two kinds, either a stratigraphical sequence, with a probable unconformity, owing to their difference in origin; or a contact of intrusion; and that portions of the Grenville and Hastings series correspond, while the latter is carried upward through less altered sediments to the upper members of the Huronian system.

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[1] Canadian Geological Nomenclature, by R. W. ELLS: Trans. Royal Soc. of Canada, 2d series, Vol. V, sec. IV, 1899, pp. 3–38.

In the Lake Superior region the Huronian is succeeded upward by the rocks of the Cambrian, represented by the Upper Copper-bearing series, or the Animikie and Nipigon groups; while in eastern Ontario this portion of the scale is apparently entirely lacking, the formation succeeding the crystalline series being the Potsdam sandstone, which is now held to represent the lowest number of the Cambro-Silurian or Ordovician system.

Comment.— Adequate discussion of the above scheme of nomenclature is quite impossible in the space available. It may be said only that the scheme will be dissented from on many important points by many of the United States geologists.

Crosby[1] describes the Archean-Cambrian contact near Manitou, Col. A sandstone of Cambrian age rests upon an Archean granite complex. The granite floor has very small erosion inequalities. These inequalities are hummocks, not hollows; erosion remnants, and not channels; clearly marking the end, and not the beginning of a process of base-leveling.

It is believed that such an even contact plane between the Cambrian and pre-Cambrian series is widespread and characteristic in North America. It appears to be the case in the valley of the Eagle River and in the canyon of the Grand River above Glenwood, Col.; in the Black Hills of South Dakota, examined by the writer; in the Grand Canyon of the Colorado, described by Walcott; and in Wisconsin, described by Irving.

In the Manitou, Eagle River, and Black Hills areas, throughout the Rocky Mountains, and eastward to Champlain Valley and beyond, the Cambrian has a non-arkose character; it has been thoroughly sorted and washed by water, a fact which indicates that the incursion of the sea was an extremely slow one. It is believed that the plane surface of the Archean has resulted from the incursion of the sea due to the subsidence of the land, and not from the action of subaerial agents, for in the latter case only an approximate plane could have resulted because of differential erosion.

Emmons[2] describes the Archean rocks of the Ten-mile quadrangle of Colorado. These rocks outcrop to the east of the great fault — the

[1] Archean-Cambrian Contact near Manitou, Col., by W. O. CROSBY: Bull. Geol. Soc. Am., Vol. X, 1899, pp. 141–164.

[2] Ten-mile District Special Folio, Colorado, by S. F. EMMONS: Geol. Atlas of the U. S., No. 48, 1898.

Mosquito fault—running north of Leadville. They consist of granites, granite-gneisses, mica-schists, and amphibolites, with pegmatite veins traversing them in every direction. Gneisses and schists are the prevailing types.

A small patch of Cambrian sediment is found resting unconformably on the Archean to the east of the Mosquito fault.

Hague[1] describes the Archean rocks of the area covered by the Absaroka folio in the northwestern part of the state of Wyoming. These consist of crystalline-schists and gneisses, mainly mica-gneiss, amphibolites, and schists distinctly light colored, which are found only in the northeastern part of the Crandall quadrangle.

Sedimentary rocks of middle Cambrian age overlie the Archean rocks unconformably.

Irving[2] gives a detailed description of the geology of an area in the northern Black Hills of South Dakota. The Algonkian rocks consist of quartzites, slates, phyllites, and schists, all of sedimentary origin. No new point is added concerning the stratigraphy of the pre-Cambrian rocks.

C. K. LEITH.

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[1] Absaroka Folio, Wyoming, by ARNOLD HAGUE: Geol. Atlas of the U. S., No. 52, 1899.

[2] A Contribution to the Geology of the Northern Black Hills, by JOHN DUER IRVING: Annals N. Y. Acad. Sci., Vol. XII, 1899, Pt. 9, pp. 187–340.